Development of Ultrananocrystalline Diamond (UNCD) Coatings for Industrial Applications

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Motivation

- UNCD provides extremely hard, low-friction coatings
- Coating industrial components with UNCD will reduce wear resulting in substantial energy savings and environmental benefits

Objectives

- Develop fundamental understanding of UNCD growth processes
  - Microwave plasma CVD process
  - Substrate seeding effects
- Develop batch coating methods to demonstrate commercial viability
- Improve UNCD adhesion using surface pretreatments

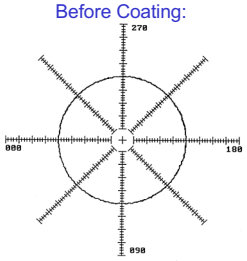
Batch Coating of Multiple Seals

- Batch coating will increase throughput to improve efficiency
- 6 automotive seals (1" OD sintered SiC) were coated simultaneously
- Coated seals were inspected with Raman, SEM, profilometry and adhesion testing

6 Automotive Seals Installed on Graphite Susceptor:

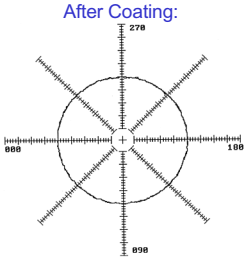
Profiler Flatness Testing:

Before Coating:



Flatness=4.2 μinch

After Coating:



Flatness=5.1 μinch

- Multiple Coated Seals Meet Target Flatness of < 33 μinch

Impact

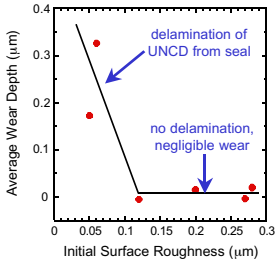
- 1,000,000 chemical process pumps in U.S.
  - Assuming 80% market penetration
- Significant energy savings from 20% lower friction losses
  - 236 trillion Btu savings cumulative by 2020
- Substantial economic benefit
  - $3.5 billion savings cumulative by 2020
- Environmental benefits
  - 4,700,000 TCE reduction cumulative by 2020

Effect of SiC Seal Surface Pretreatment on UNCD Adhesion

Chemical Process Pump Seal

Seal Installed in Graphite Susceptor

Seal Testing Fixture

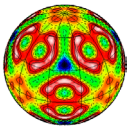


- High Initial Surface Roughness Improves UNCD Adhesion to SiC Seal Surface
- UNCD Coating Enhances SiC Seal Lifetime

Future Directions

- Continue testing UNCD coated seals using industrial partners' facilities (friction tests, dry running tests, thermal shock tests, etc.)
- Upgrade to 11" IPlas UNCD deposition system
- Investigate other applications of UNCD for industrial energy savings such as electrochemical sensors and additional tribomechanical coating applications

"Ultrananocrystalline diamond film as a wear resistant and protective coating for mechanical seal applications", A. V. Sumant, A. R. Krauss, D. M. Gruen, O. Auciello, A. Erdemir, M. Williams, A. F. Artiles and W. Adams, Tribol. Trans. J., Submitted, 2003.



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